University of Massachusetts Medical School
eScholarship@UMMS

PEER Liberia Project | UMass Medical School Collaborations in Liberia

2021-04-22

Acute Stroke Imaging

Jose Gavito-Higuera
RAD-AID

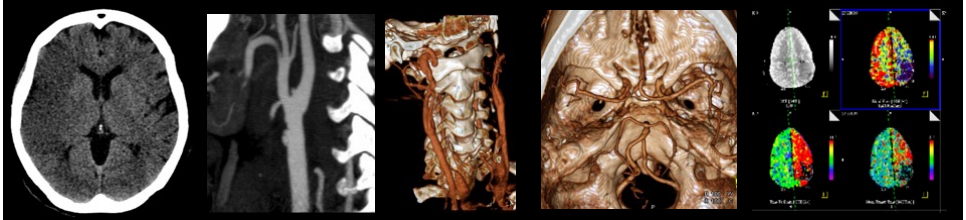
Let us know how access to this document benefits you.
Follow this and additional works at: https://escholarship.umassmed.edu/liberia_peer

 Part of the Cardiovascular Diseases Commons, Diagnosis Commons, Family Medicine Commons, Medical Education Commons, Nervous System Diseases Commons, and the Radiology Commons

Repository Citation
Gavito-Higuera J. (2021). Acute Stroke Imaging. PEER Liberia Project. https://doi.org/10.13028/kdpq-he34. Retrieved from https://escholarship.umassmed.edu/liberia_peer/75

This material is brought to you by eScholarship@UMMS. It has been accepted for inclusion in PEER Liberia Project by an authorized administrator of eScholarship@UMMS. For more information, please contact Lisa.Palmer@umassmed.edu.

Acute Stroke Imaging



TEXAS TECH UNIVERSITY HEALTH SCIENCES CENTER EL PASO

Jose Gavito-Higuera, MD
Assistant Professor, Neuroradiology
Texas Tech University Health Sciences Center
University Medical Center of El Paso
El Paso, Texas
jose.gavito@ttuhsc.edu

1

Overview:

I. Acute stoke imaging algorithm

II. CT / CTA / CTP Stroke assessment

III. Review Cases

2

"Time is Brain"

- 1.9 million neurons die each minute in which stroke is untreated
- But it depends on if you are a slow, moderate or fast progressor and this may be dependent on individual collaterals

3

"Time is Brain"

Success of acute stroke intervention depends on :

- Patient selection
- Symptom onset to treatment time

4

Acute Stroke – Clinical Evaluation

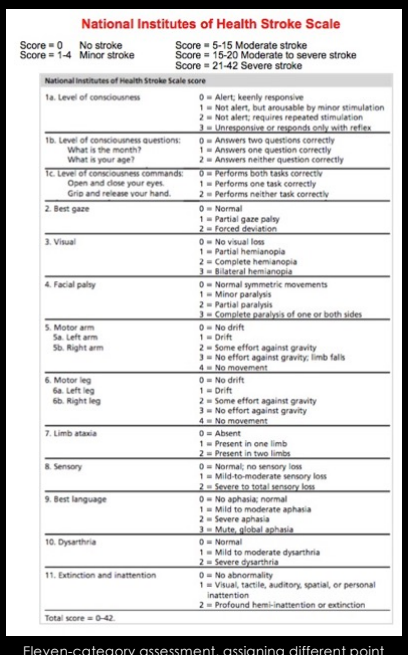
- Neurological exam
  - National Institutes of Health Stroke Scale
- Time of symptom onset
  - < 3 – 4.5 hrs IV tPA
  - < 6 hrs IA therapy
- tPA inclusion / exclusion
  - ACEP/AAN (2013)

ECASS III study
Hacke W, At al NEJM, 2008

5

- National Institutes of Health Stroke Scale (NIHSS)

Score:
0 : No Stroke
1- 4 : Minor Stroke
5 – 15 : Moderate Stroke
16 – 20 : Moderate to Severe
21 – 42 : Severe Stroke



National Institutes of Health Stroke Scale

Score = 0 No stroke
Score = 1-4 Minor stroke
Score = 5-15 Moderate stroke
Score = 15-20 Moderate to severe stroke
Score = 21-42 Severe stroke

National Institutes of Health Stroke Scale score	
1a. Level of consciousness	0 = Alert; keenly responsive 1 = Not alert, but arousable by minor stimulation 2 = Not alert; requires repeated stimulation 3 = Unresponsive or responds only with reflex
1b. Level of consciousness questions: What is the month? What is your age?	0 = Answers two questions correctly 1 = Answers one question correctly 2 = Answers neither question correctly
1c. Level of consciousness commands: Open and close your eyes. Grip and release your hand.	0 = Performs both tasks correctly 1 = Performs one task correctly 2 = Performs neither task correctly
2. Best gaze	0 = Normal 1 = Partial gaze palsy 2 = Forced deviation
3. Visual	0 = No visual loss 1 = Partial hemianopia 2 = Complete hemianopia 3 = Bilateral hemianopia
4. Facial palsy	0 = Normal symmetric movements 1 = Minor paralysis 2 = Partial paralysis 3 = Complete paralysis of one or both sides
5. Motor arm 5a. Left arm 5b. Right arm	0 = No drift 1 = Drift 2 = Some effort against gravity 3 = No effort against gravity; limb falls 4 = No movement
6. Motor leg 6a. Left leg 6b. Right leg	0 = No drift 1 = Drift 2 = Some effort against gravity 3 = No effort against gravity 4 = No movement
7. Limb ataxia	0 = Absent 1 = Present in one limb 2 = Present in two limbs
8. Sensory	0 = Normal; no sensory loss 1 = Mild-to-moderate sensory loss 2 = Severe to total sensory loss
9. Best language	0 = No aphasia; normal 1 = Mild to moderate aphasia 2 = Severe aphasia 3 = Mute, global aphasia
10. Dysarthria	0 = Normal 1 = Mild to moderate dysarthria 2 = Severe dysarthria
11. Extinction and inattention	0 = No abnormality 1 = Visual, tactile, auditory, spatial, or personal inattention 2 = Profound hemi-inattention or extinction
Total score = 0–42.	

Eleven-category assessment, assigning different point value to different function

6

Acute Stroke – Clinical Evaluation

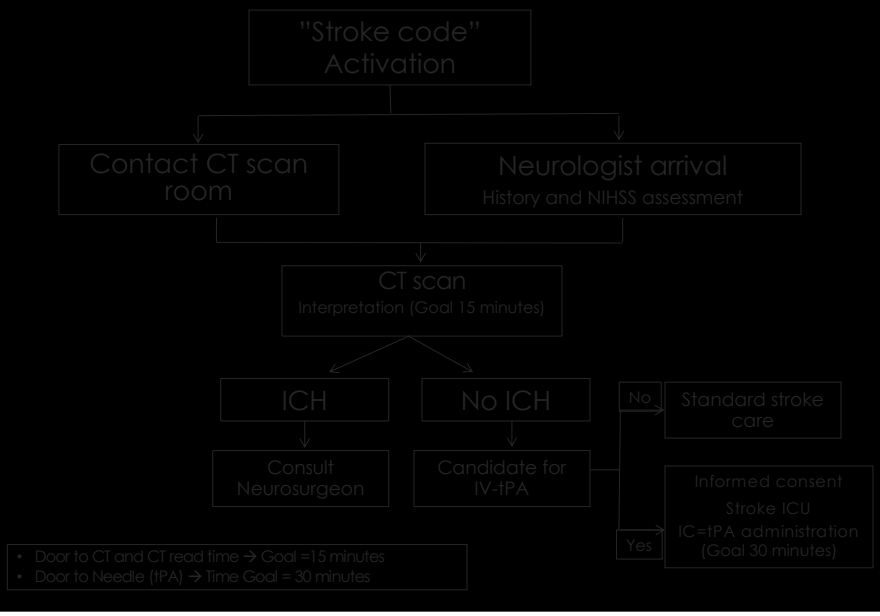
- Neurological exam
  - National Institutes of Health Stroke Scale
- Time of symptom onset
  - < 3 – 4.5 hrs IV tPA
  - < 6 hrs IA therapy
- tPA inclusion / exclusion
  - ACEP/AAN (2013)

ECASS III study
Hacke W, At al NEJM, 2008

The other clinical component is the time of stoke. There are multiple studies (tPA has benefit but only in a certain time of window).

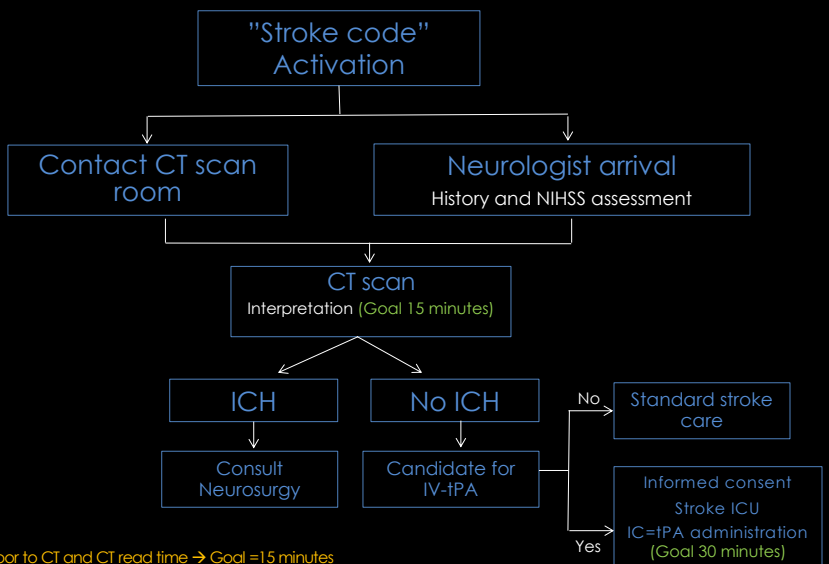
7

Stroke Activation Protocol



8

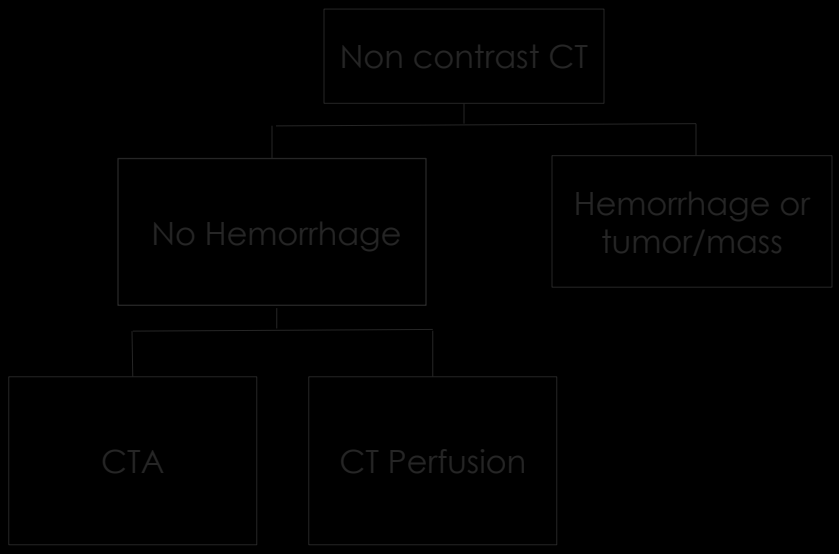
Stroke Activation Protocol



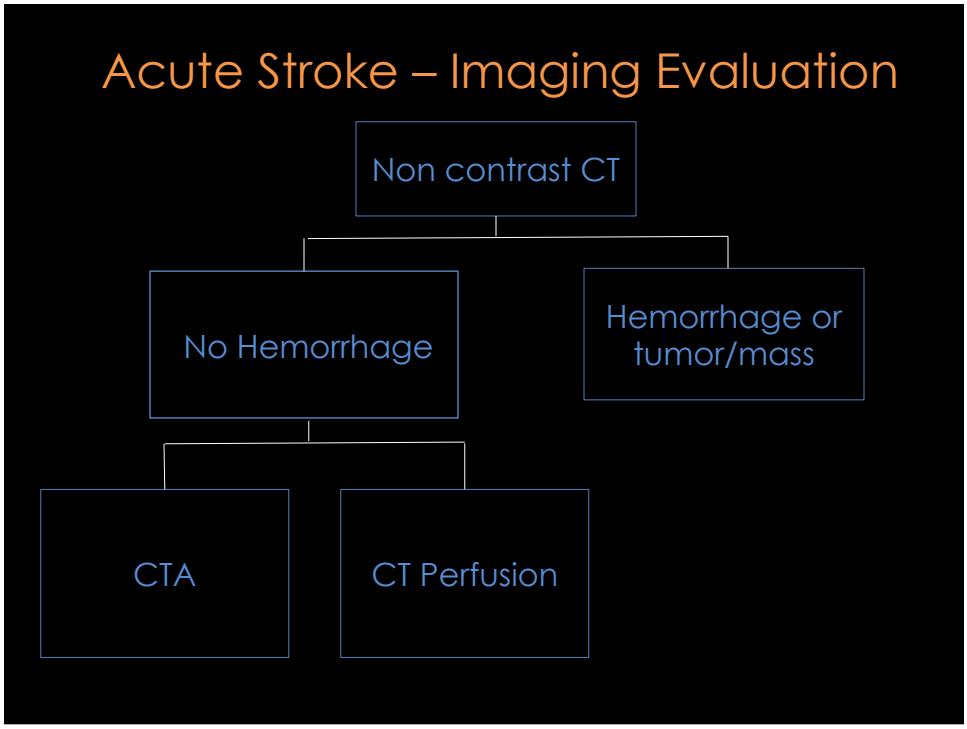
- Door to CT and CT read time → Goal =15 minutes
- Door to Needle (tPA) → Time Goal = 30 minutes

9

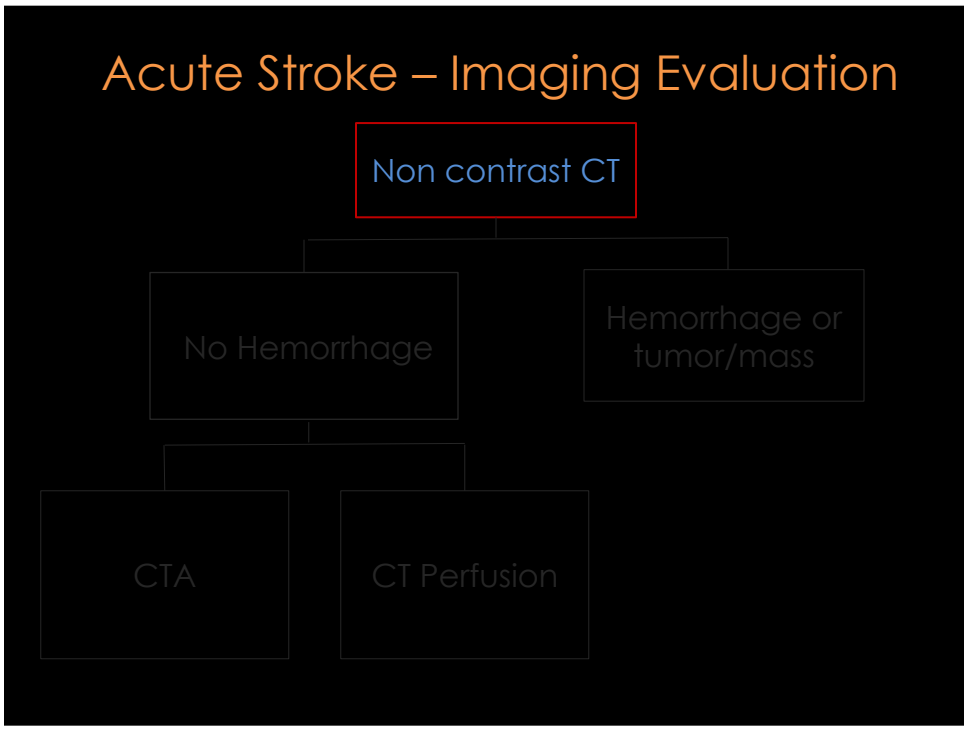
Acute Stroke – Imaging Evaluation



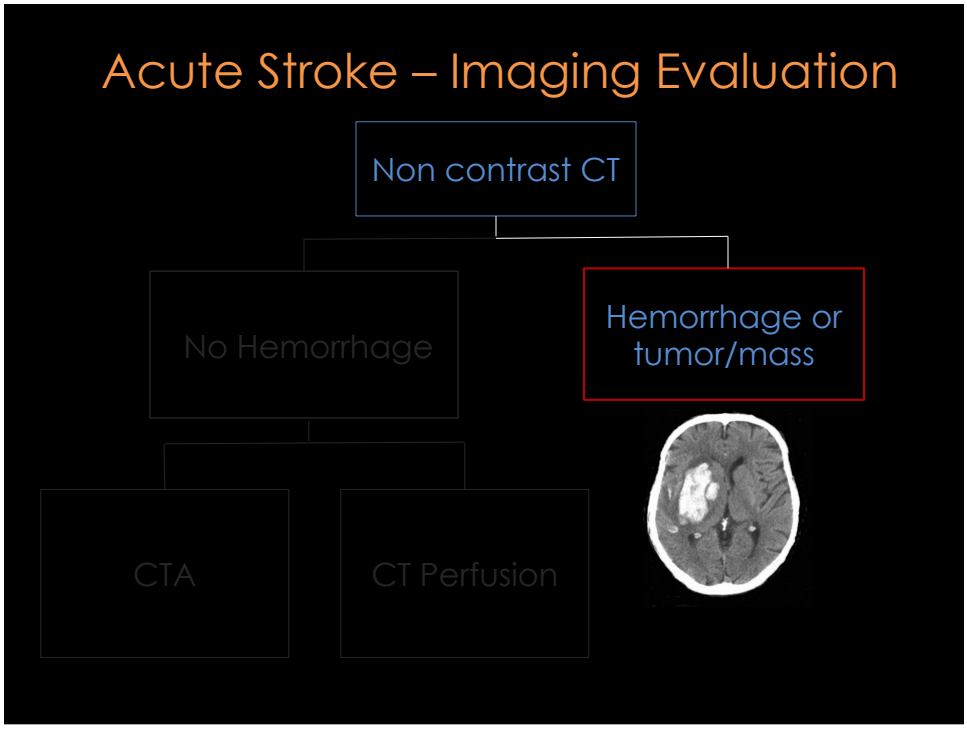
10


Acute Stroke – Imaging Evaluation
Non contrast CT
No Hemorrhage
Hemorrhage or tumor/mass
CTA
CT Perfusion

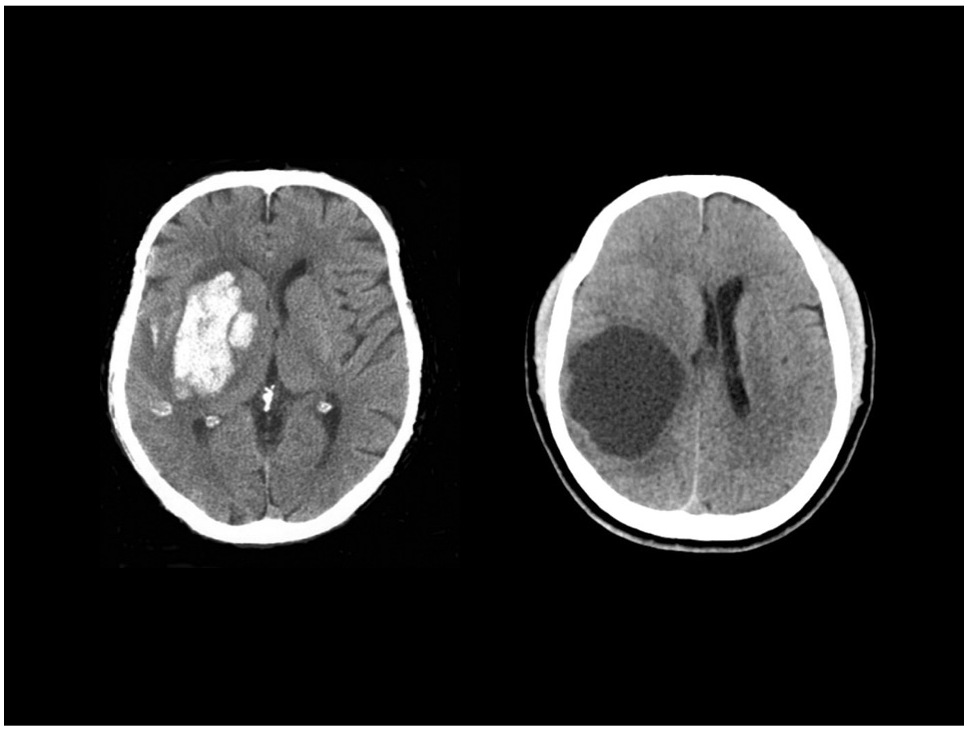
11


Acute Stroke – Imaging Evaluation
Non contrast CT
No Hemorrhage
Hemorrhage or tumor/mass
CTA
CT Perfusion

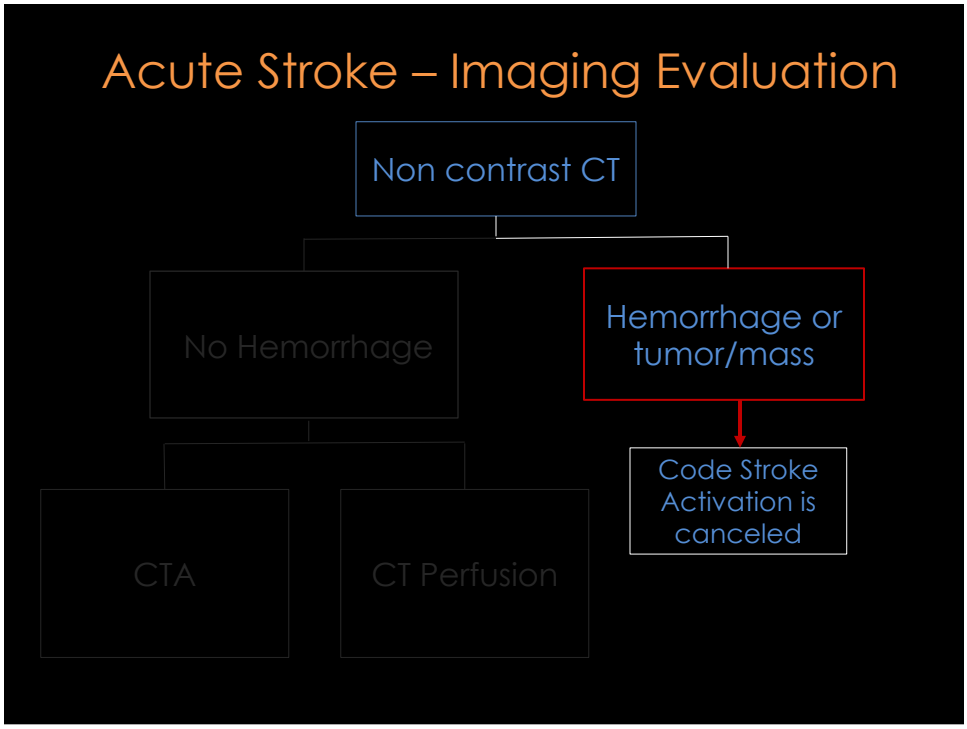
12


Acute Stroke – Imaging Evaluation
Non contrast CT
No Hemorrhage
Hemorrhage or tumor/mass
CTA
CT Perfusion

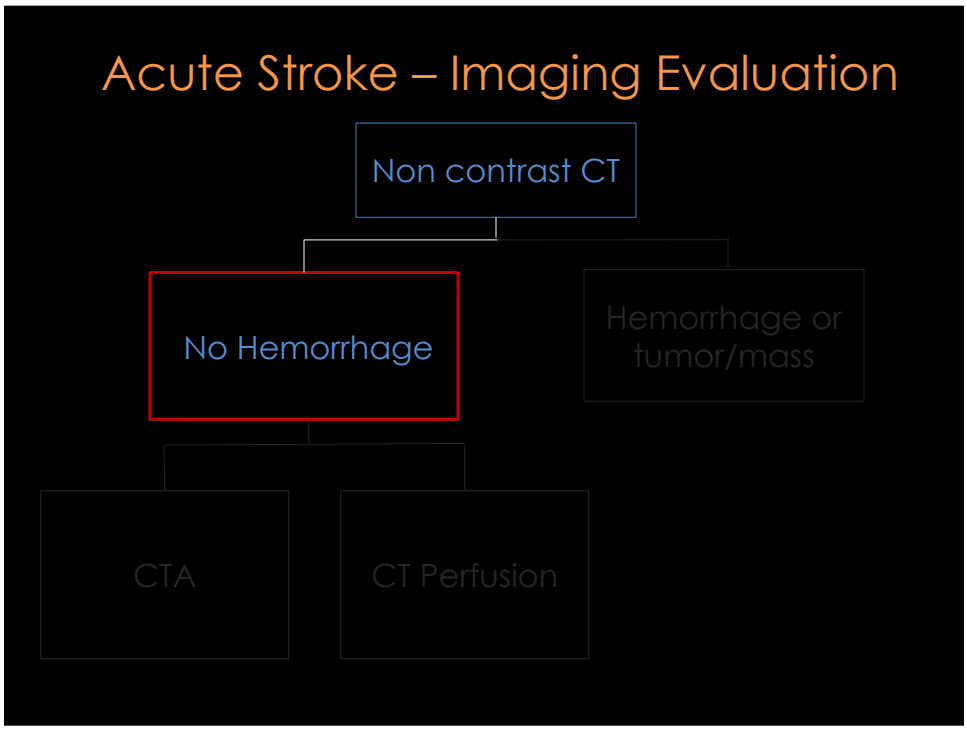
13



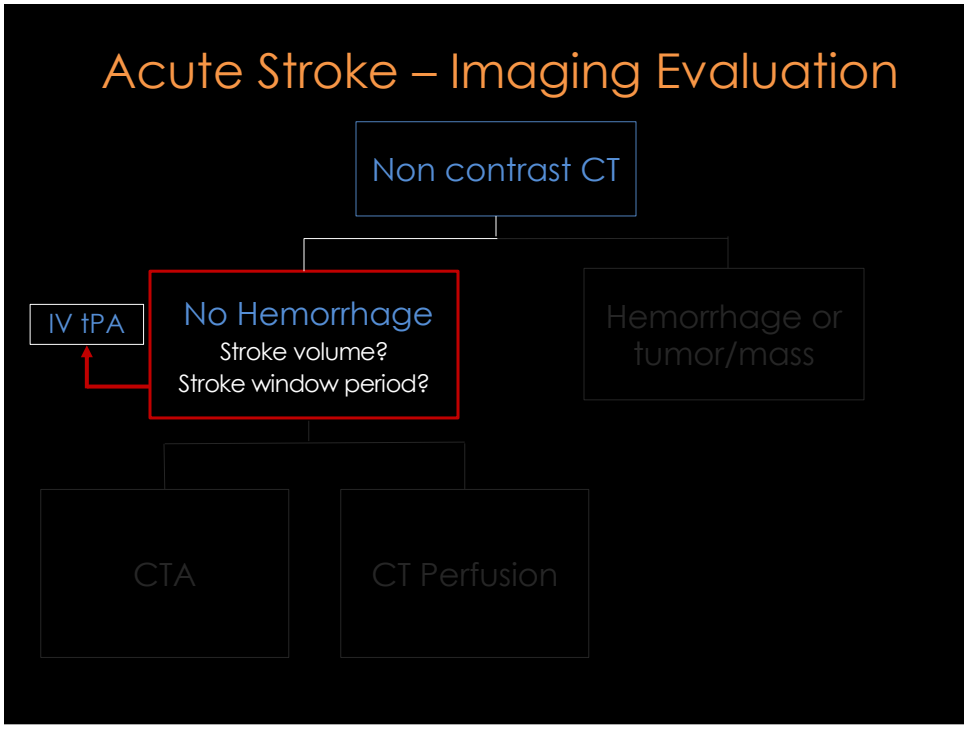
14


Acute Stroke – Imaging Evaluation
Non contrast CT
No Hemorrhage
Hemorrhage or tumor/mass
Code Stroke Activation is canceled
CTA
CT Perfusion

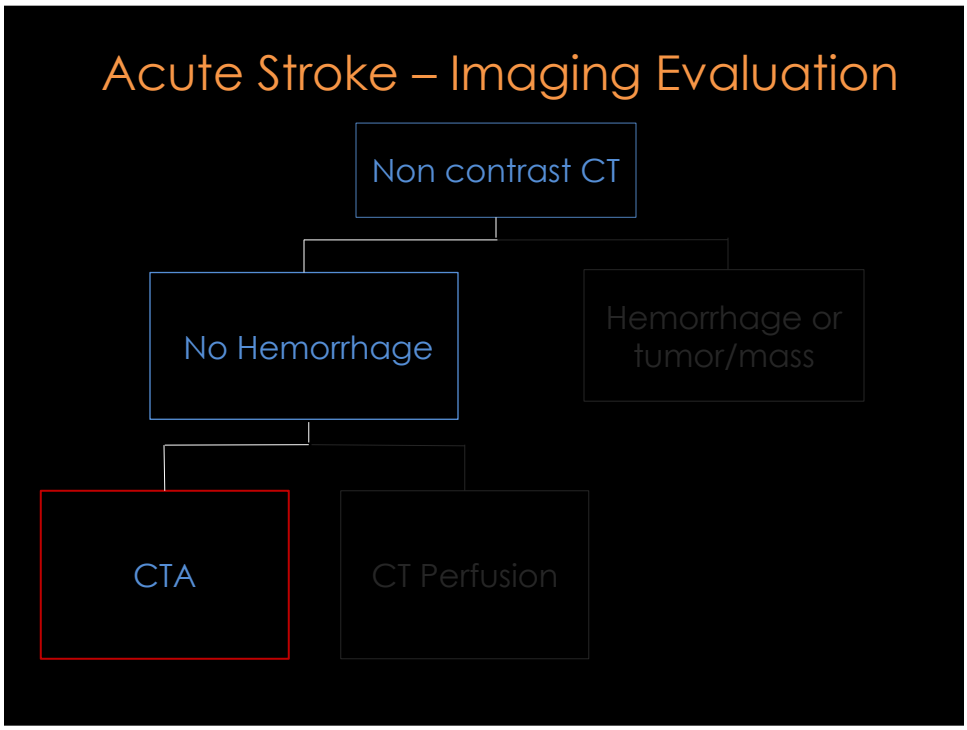
15


Acute Stroke – Imaging Evaluation
Non contrast CT
No Hemorrhage
Hemorrhage or tumor/mass
CTA
CT Perfusion

16


Acute Stroke – Imaging Evaluation
Non contrast CT
IV tPA
No Hemorrhage
Stroke volume?
Stroke window period?
Hemorrhage or tumor/mass
CTA
CT Perfusion

17


Acute Stroke – Imaging Evaluation
Non contrast CT
No Hemorrhage
Hemorrhage or tumor/mass
CTA
CT Perfusion

18

Acute Stroke – Imaging Evaluation

Non contrast CT

No Hemorrhage

Hemorrhage or tumor/mass

CTA

LVO?

Collaterals?

19

Acute Stroke – Imaging Evaluation

Non contrast CT

No Hemorrhage

Hemorrhage or tumor/mass

CTA

CT Perfusion

20

Acute Stroke – Imaging Evaluation

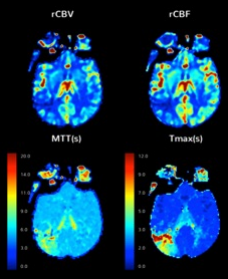
Non contrast CT

No Hemorrhage

Hemorrhage or tumor/mass

CTA

CT Perfusion
- Core?
- Penumbra?
- Perfusion mismatch?



21

Acute Stroke – Imaging Evaluation

Non contrast CT

No Hemorrhage
- Stroke volume?
- Stroke window period?

Hemorrhage or tumor/mass

CTA

CT Perfusion

22

CT signs of ACUTE stroke:

- Hypoattenuation
- Loss of gray white matter differentiation
- Sulcal effacement and mass effect
- Hyperdense vessel sign (MCA, dot-M2)

23

Loss of gray white matter differentiation

- Basal ganglia sign

- Insular ribbon sign

24

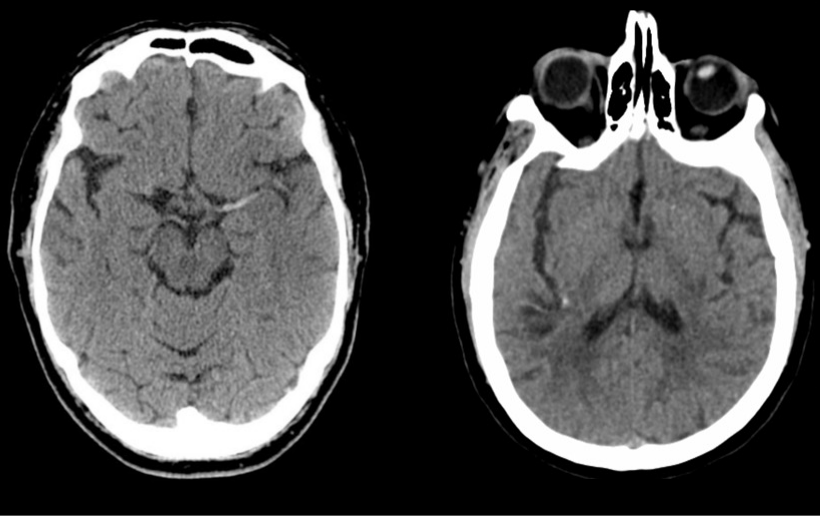
CT signs of ACUTE stroke:

- Hypoattenuation
- Loss of gray white matter differentiation
- Sulcal effacement and mass effect
- Hyperdense vessel sign (MCA, dot-M2)

25

Correlating finding?

- Dense MCA sign



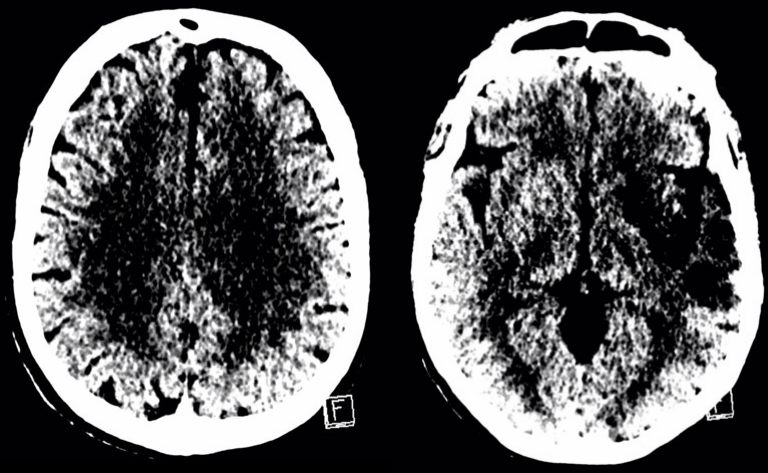
26

Case 1:

What CT acute stroke finding shown?

a) Insular ribbon sign
b) Loss of gray white matter differentiation
c) Dense vessel sign
d) Hemorrhagic conversion

27

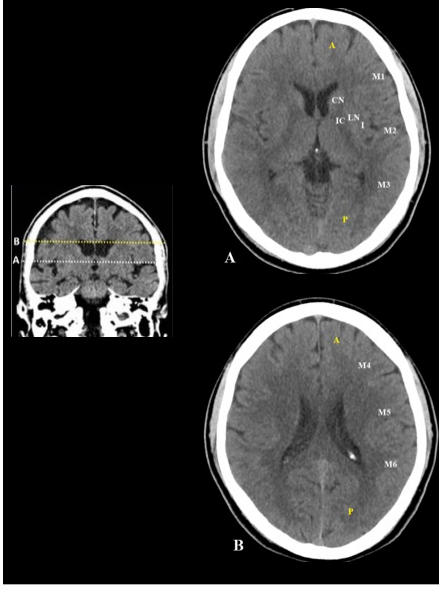


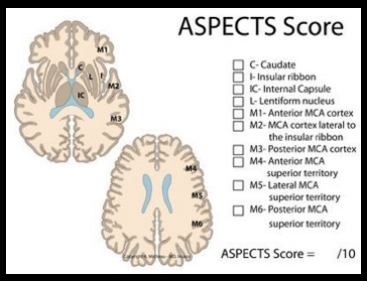
Stroke window level 32 HU/ width 8 HU

28

CT stroke Volume

- Alberta stroke program early CT score (ASPECTS)



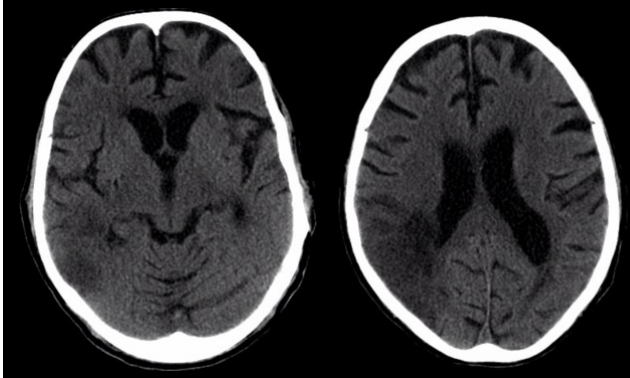


Practical points:

- Total 10 MCA territory allotted where each area equals to 1 point
- Normal CT scan receive a score of 10 points
- A score of <7 is equal to one-third of the MCA territory
- A score of zero indicates diffuse ischemia involvement throughout the MCA territory

29

Case 2:

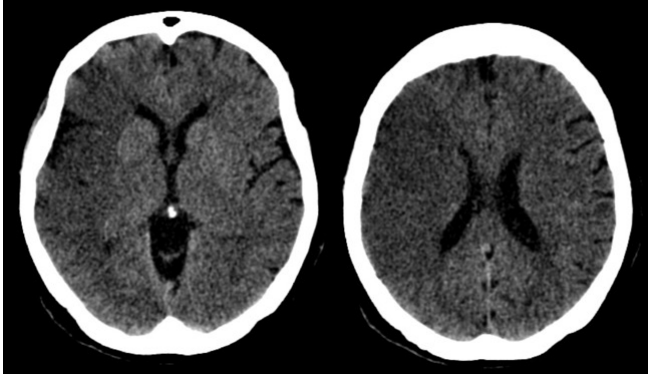


ASPECTS score?

a) 10
b) 9
c) 8
d) 7
e) 6
f) 5

30

Case 3:

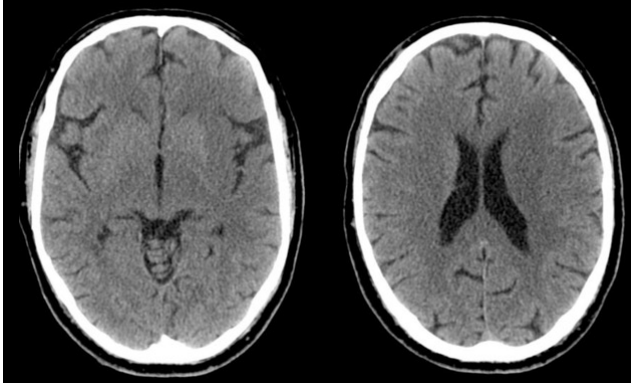


ASPECTS score?

a) 7
b) 6
c) 5
d) 4
e) 3
f) 2

31

Case 4:



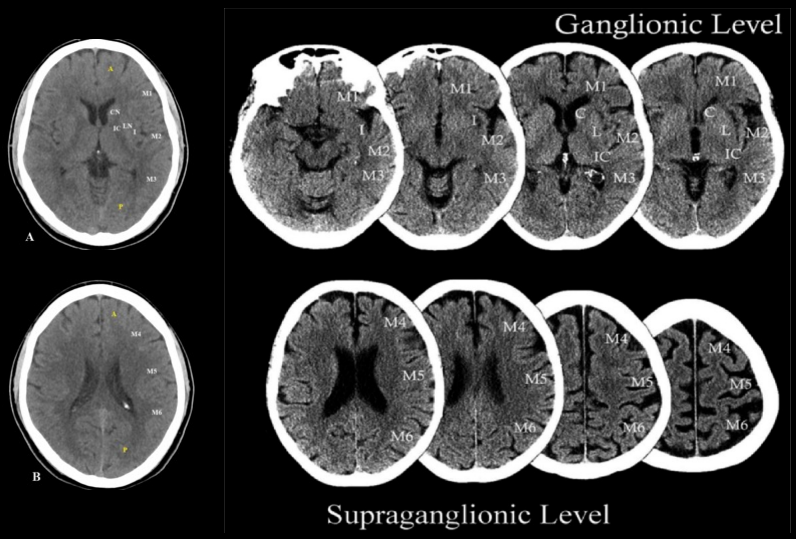
ASPECTS score?

a) 10
b) 9
c) 8
d) 7
e) 6
f) 5

32

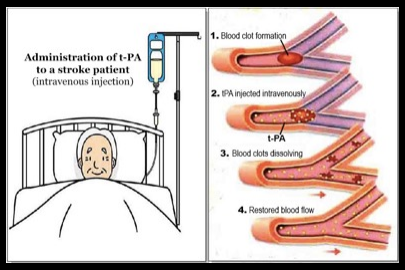
CT stroke Volume

- Alberta stroke program early CT score (ASPECTS)



33

Question 1:



Which of the following most likely makes a patient ineligible for IV tPA?

a) No findings on head CT
b) Stroke onset 4 hrs
c) ASPECTS score of 2
d) Positive basal ganglia sing on CT

34

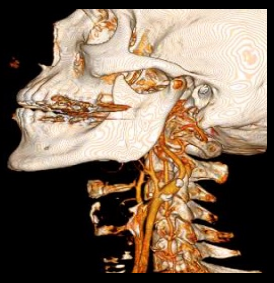
Acute Stroke – Imaging Evaluation

Non contrast CT

No Hemorrhage

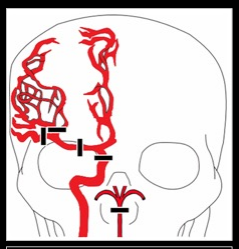
Hemorrhage or tumor/mass

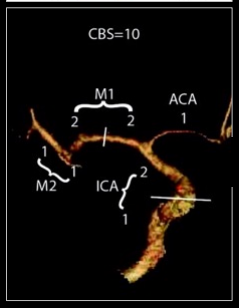
CTA
LVO?
Collaterals?

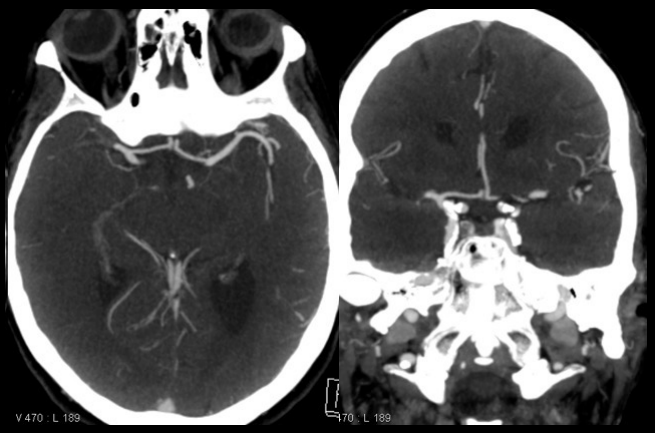


35

CTA: Large Vessel Occlusion





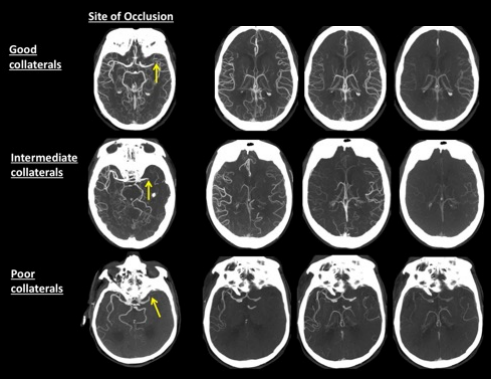


Determine site and size of occlusion

- Bad prognosis: Proximal occlusion
- Bad Prognosis: Large thrombus
- Consider mechanical embolectomy

36

Collaterals



- Good collaterals: Smaller baseline infarct core, reduced final infarct volumes and larger mismatches at triage
- Poor collaterals: Larger core and quicker infarct growth
- Amount of core growth and speed of growth may depend on collaterals

37

Acute Stroke – Imaging Evaluation

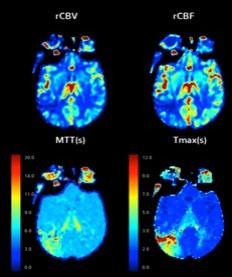
Non contrast CT

No Hemorrhage

Hemorrhage or tumor/mass

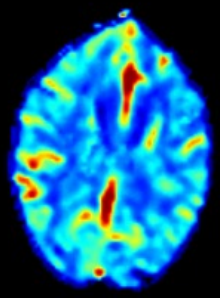
CTA

CT Perfusion
Core?
Penumbra?
Perfusion mismatch?



38

CT Perfusion

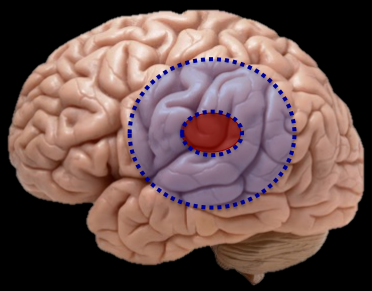


- CT perfusion (CTP) has emerged as a valuable tool in the management of acute stroke, providing essential quantitative information on the extent of the irreversibly injured ischemic core and the potentially salvageable ischemic penumbra

39

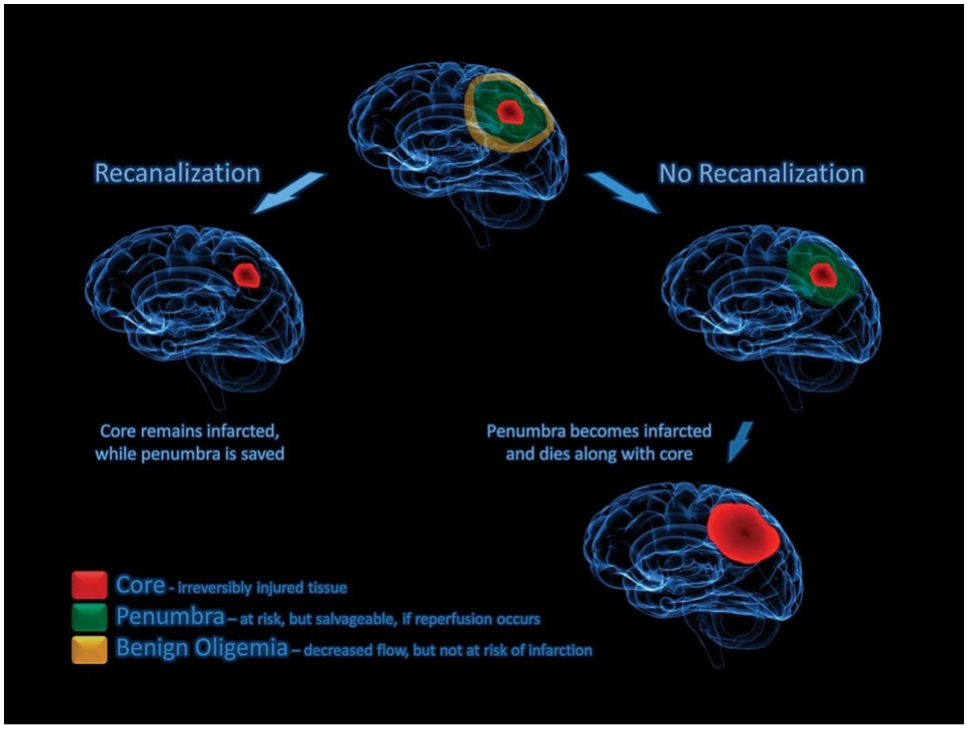
Salvageable Brain?

- Core: Irreversible injured tissue
- Penumbra: at risk, but salvageable, if reperfusion occurs



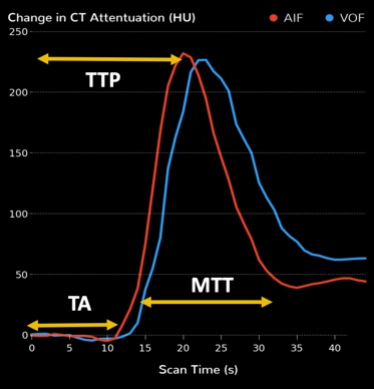
CTP help in the selection of patients for intravascular thrombolysis and endovascular revascularization

40



41

Perfusion Curve:



Measured parameters:

- Time of arrival of the contrast (TA)
- Time to Peak (TTP)
- Mean transit time (MTT)

42

Multiple Perfusion Parameters

Tissue viability:

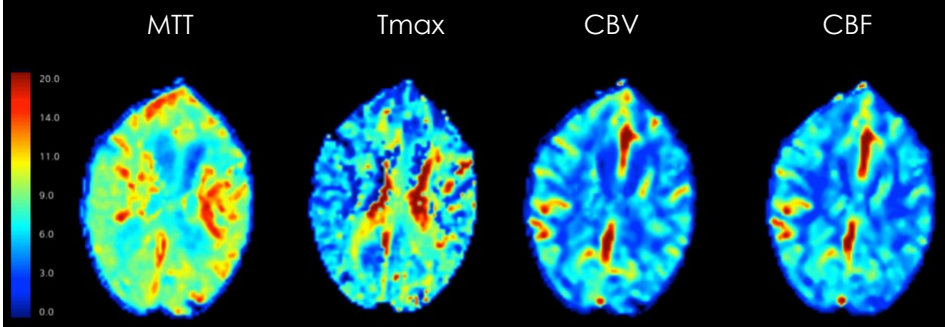
- CBF: Cerebral blood flow (nml 50-60ml/100gr/min)
- CBV: Cerebral blood volume (2-5mL/100g tissue)
- CBF = CBV / MTT

Time-sensitive:

- MTT: Mean transit time (3-5 sec, needs deconvolution)
- TTP: Time to peak (maximum contrast variation)
- TTP = Tmax: Time to max (sec, needs deconvolution)
- TA: Time of arrival of the contrast agent

43

CT Perfusion

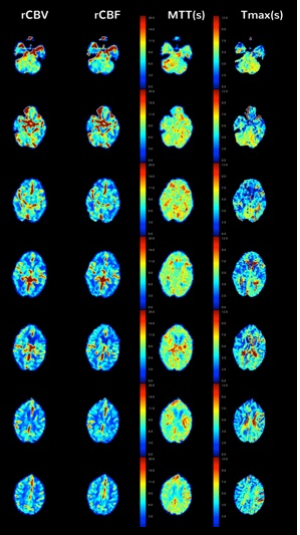


The quality of perfusion is affected by numerous factors (injection velocity, hemodynamic)

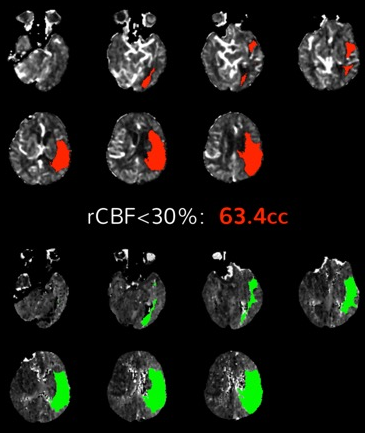
44

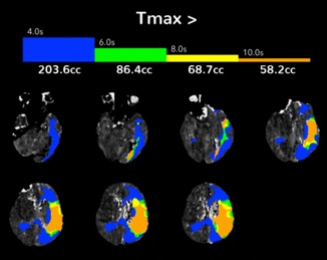
CTP Basics

- Core = Infarcted tissue, CBF or CBV can be used
  - Core < 70mL – 100mL preferred
  - CBF used for determining infarct core CBF < 30%
- Tmax > 6 sec used for tissue likely to die if not re-perfused (salvageable tissue)
  - Tmax 4s - 6s unlikely to die
- **Mismatch radio** > 1.8 or 15mL absolute between core and tissue at risk
- **Malignant profile:** Edema hemorrhage, rapid enlargement, poor outcome, poor collaterals
  - Tmax> 10 sec, >100mL (large infarct)
- **HIP =** Hypoperfusion Intensity Ratio: Evaluates portion of Tmax > 6 s with Tmax > 10 s
  - Large fraction with >10 s associated with poor outcome after reperfusion
  - HIP = < 0.4 good collaterals
  - HIP > 0.5 poor collaterals and quicker growth of infarct



45





Mismatch Volume: **23.0 cc**
Mismatch Ratio: **1.4**

46

Examples CTP

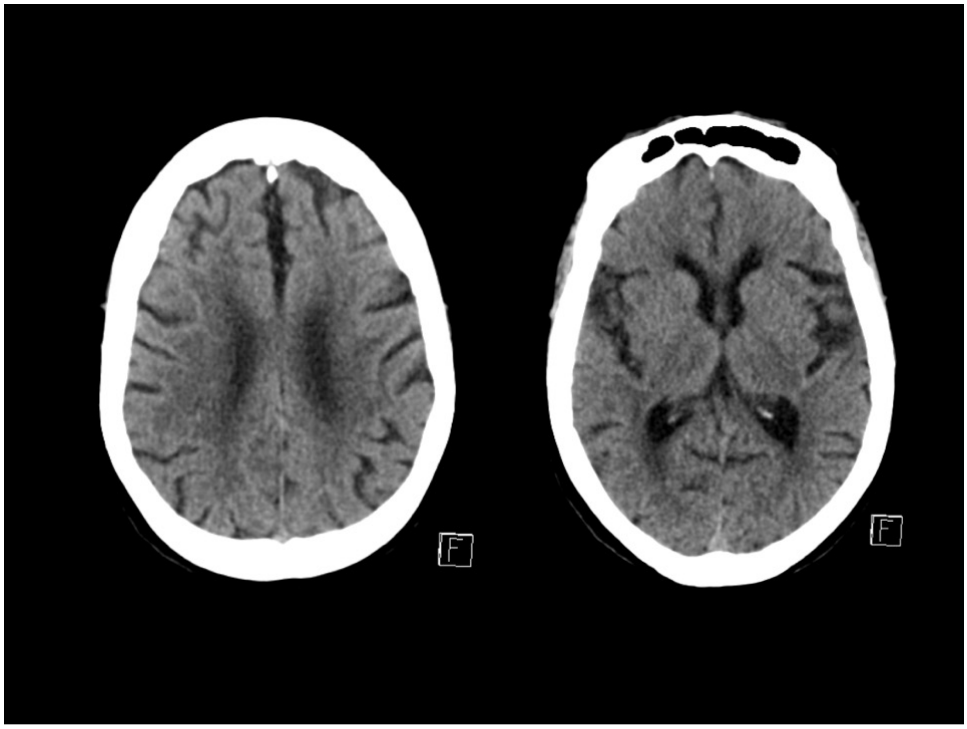
47

Case 1

88 yo F

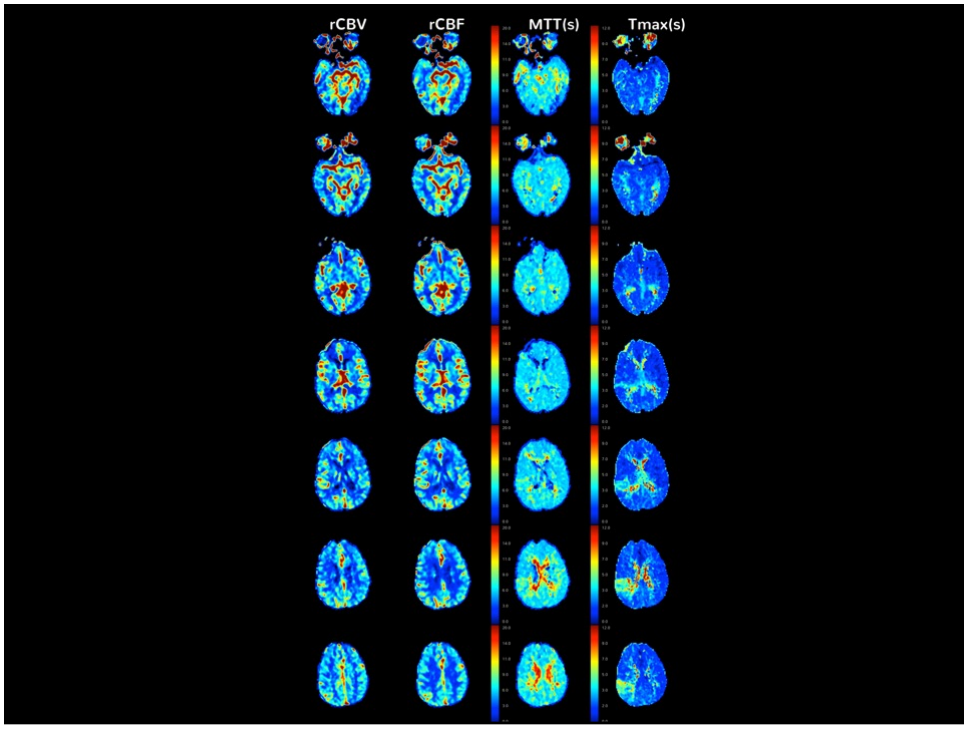
Acute onset LUE weakness, L facial droop and dysarthria

48

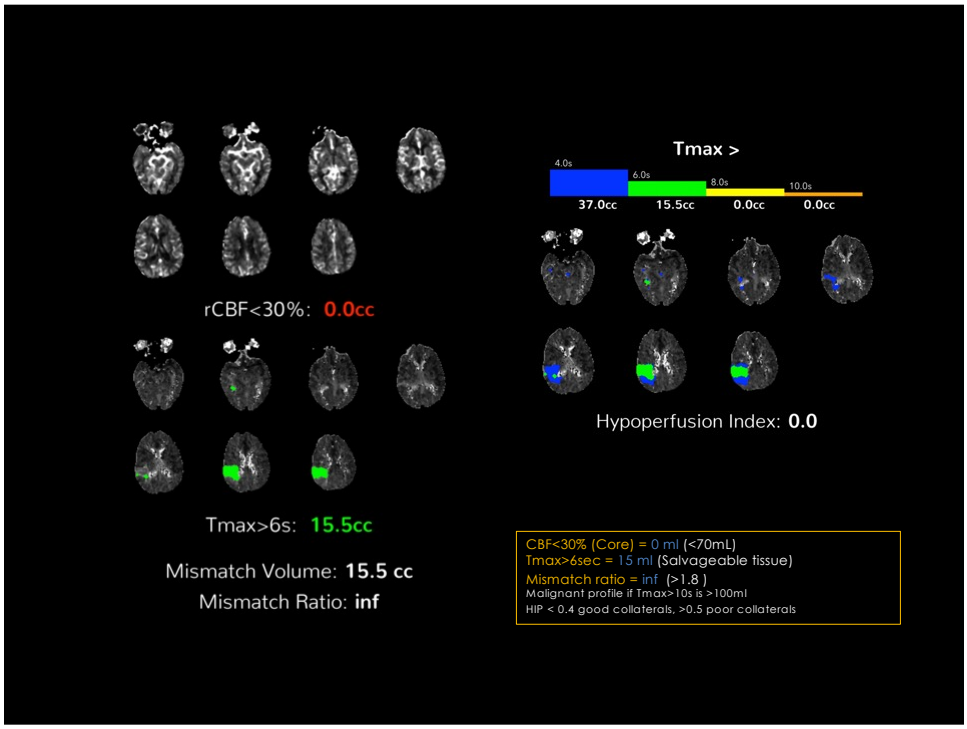


49

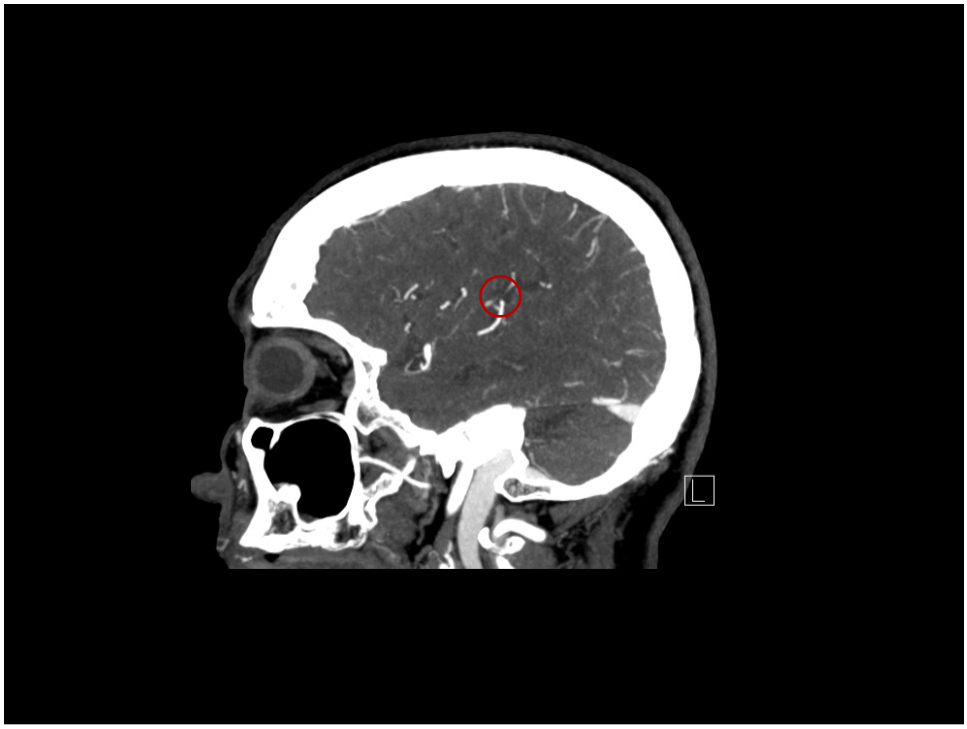
50


rCBV
rCBF
MTT(s)
Tmax(s)

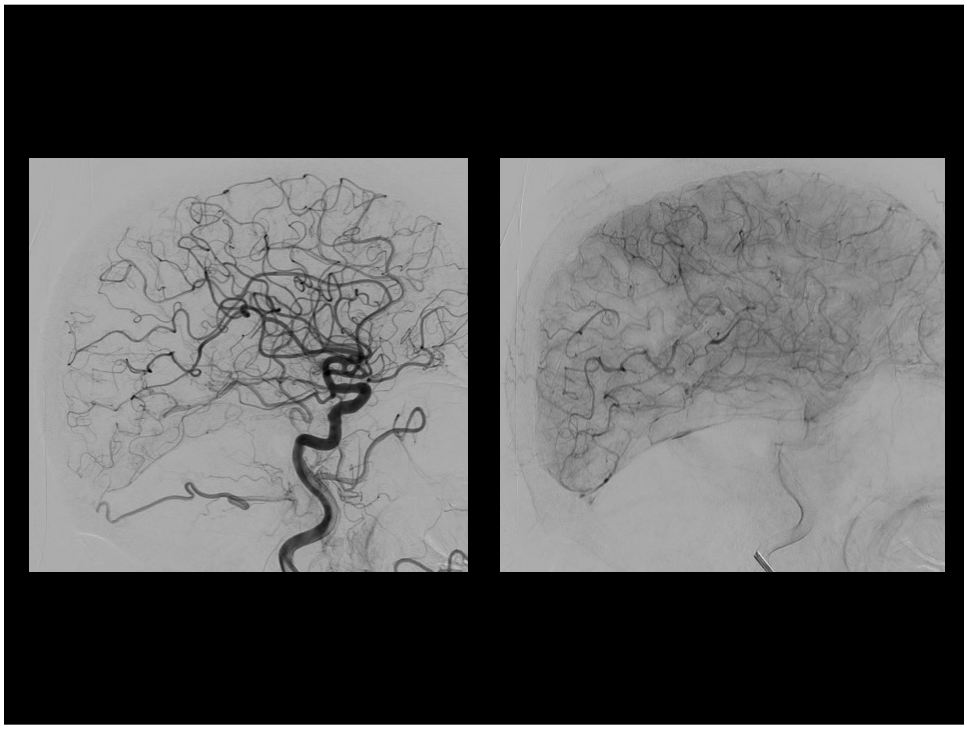
51


rCBF<30%: 0.0cc
Tmax>6s: 15.5cc
Mismatch Volume: 15.5 cc
Mismatch Ratio: inf
Tmax >
4.0s
6.0s
8.0s
10.0s
37.0cc
15.5cc
0.0cc
0.0cc
Hypoperfusion Index: 0.0
CBF<30% (Core) = 0 ml (<70mL)
Tmax>6sec = 15 ml (Salvageable tissue)
Mismatch ratio = inf (>1.8)
Malignant profile if Tmax>10s is >100ml
HIP < 0.4 good collaterals, >0.5 poor collaterals

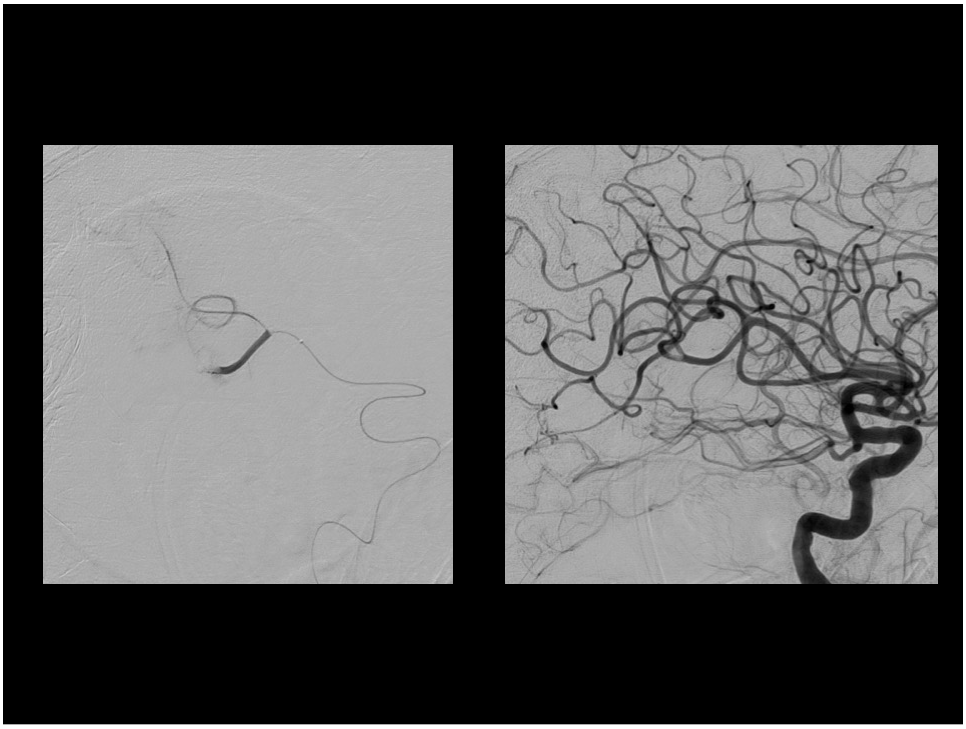
52



53



54

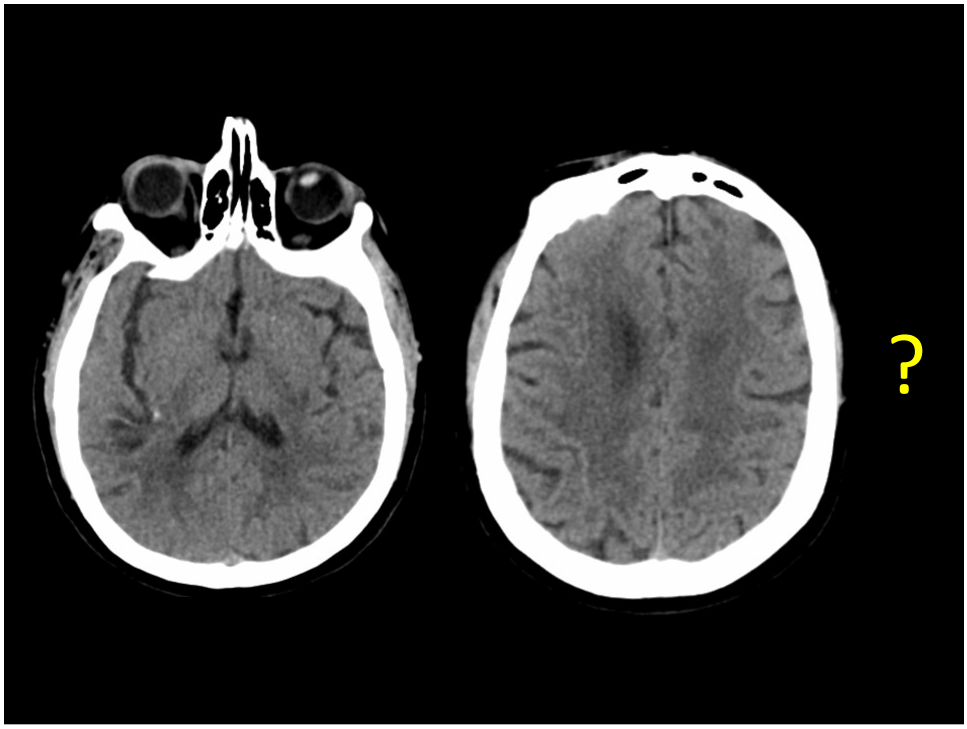


55

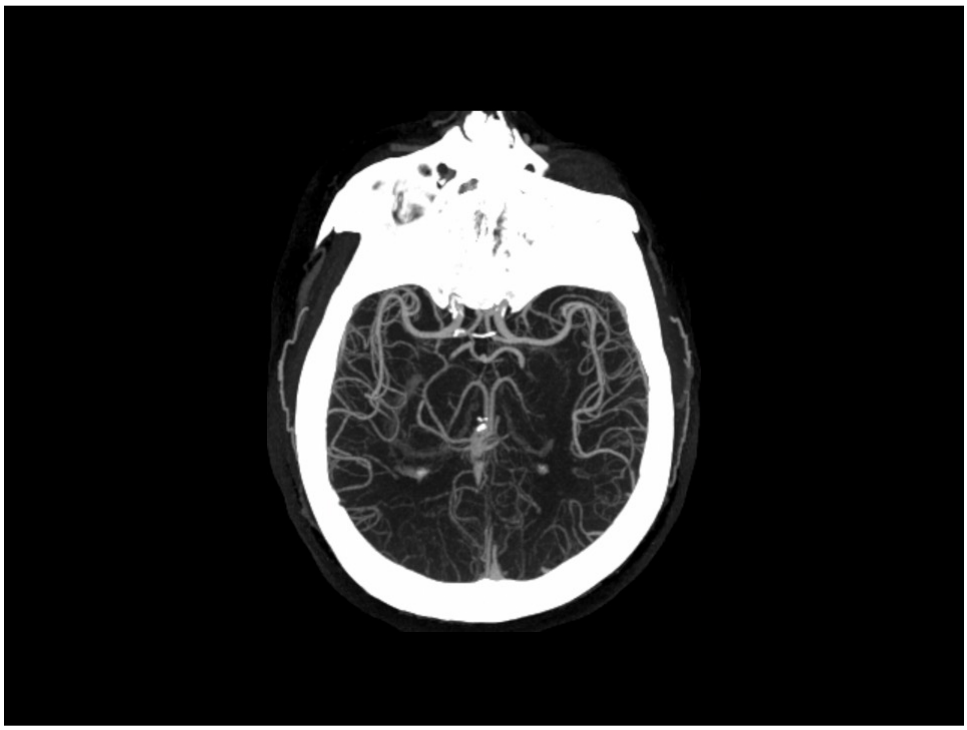
Case 2

63 yo F
Code Stroke

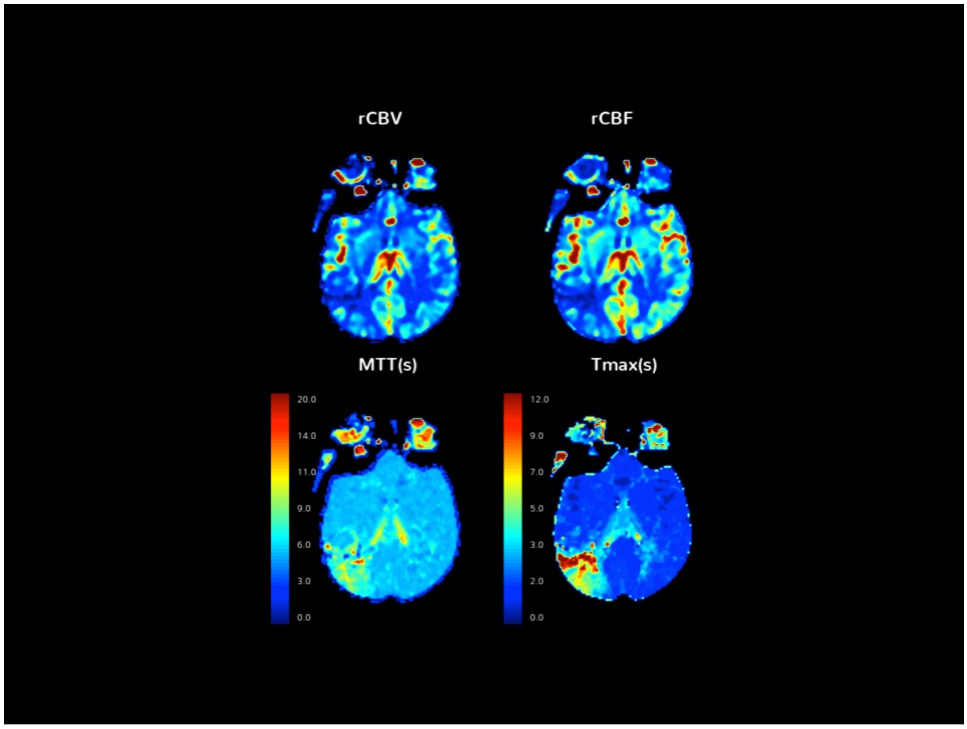
56



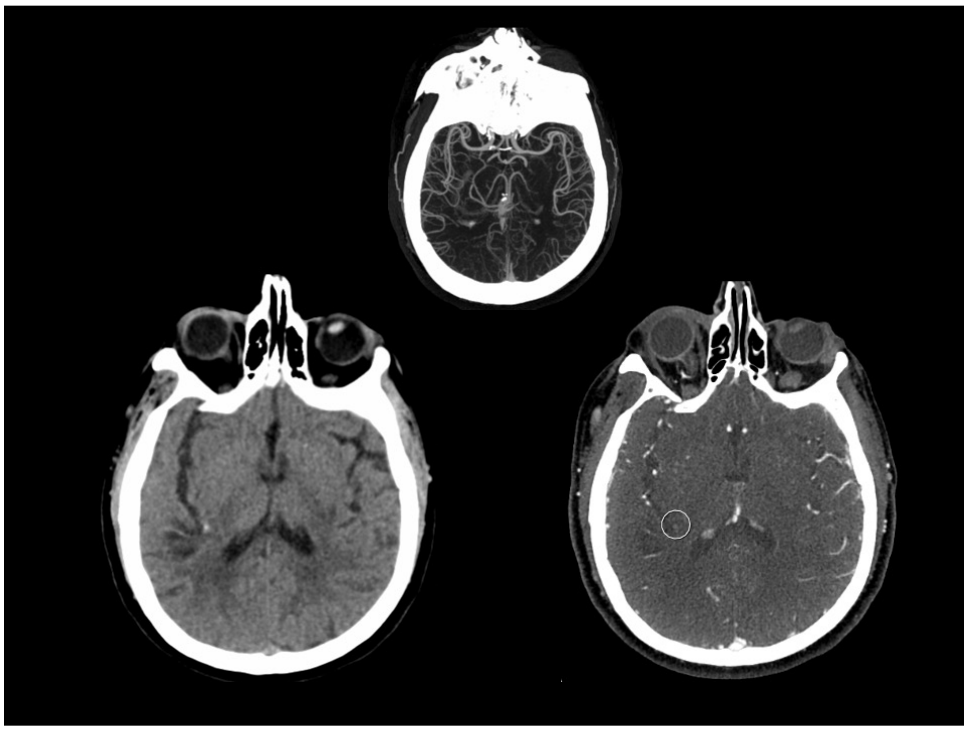
57



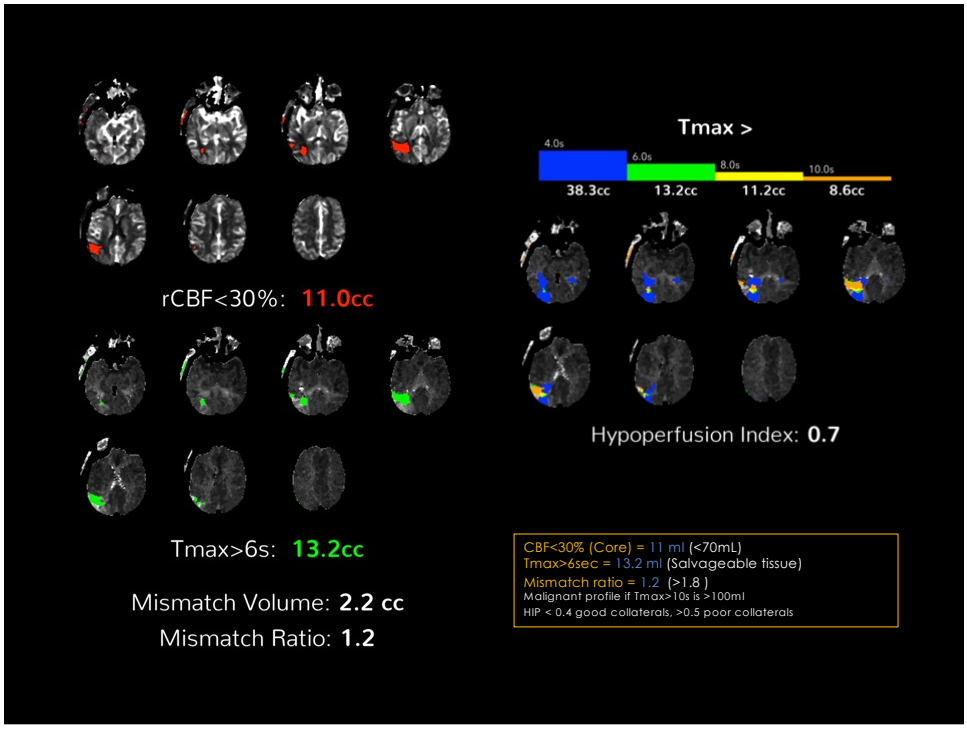
58



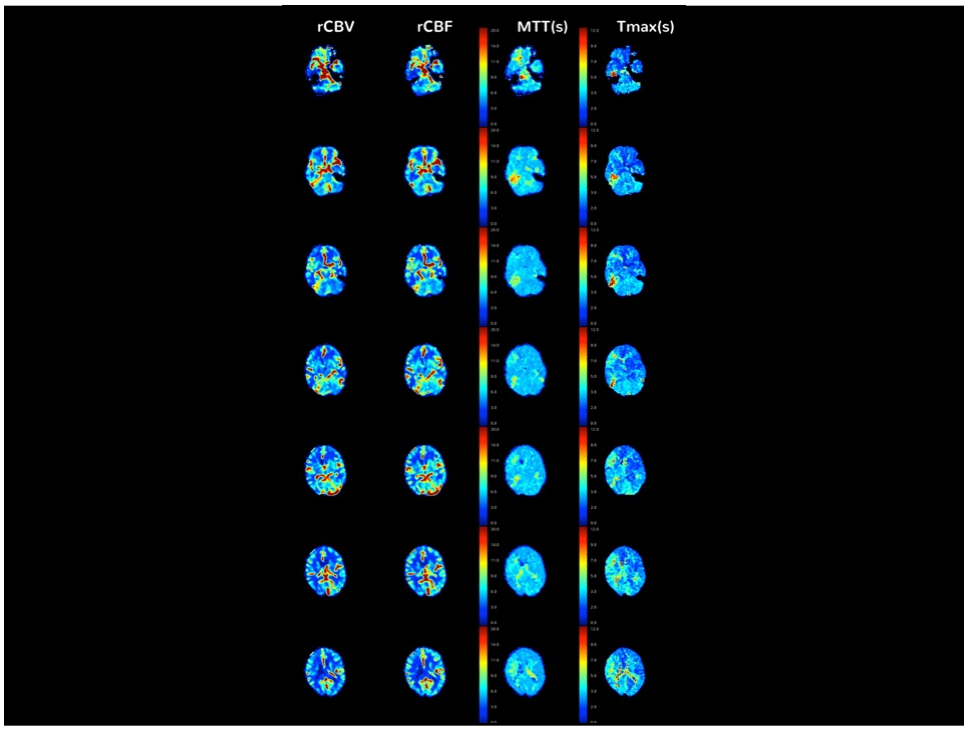
59



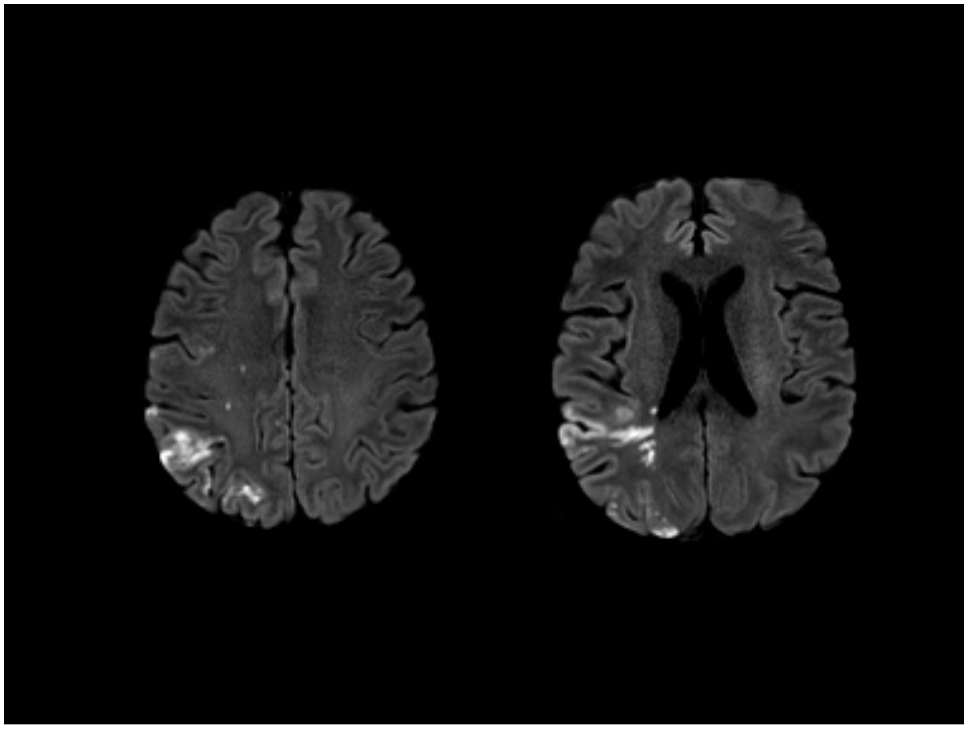
60


Tmax >
4.0s
6.0s
8.0s
10.0s
38.3cc
13.2cc
11.2cc
8.6cc
rCBF<30%: 11.0cc
Hypoperfusion Index: 0.7
Tmax>6s: 13.2cc
Mismatch Volume: 2.2 cc
Mismatch Ratio: 1.2
CBF<30% (Core) = 11 ml (<70mL)
Tmax>6sec = 13.2 ml (Salvageable tissue)
Mismatch ratio = 1.2 (>1.8)
Malignant profile if Tmax>10s is >100ml
HIP < 0.4 good collaterals, >0.5 poor collaterals

61

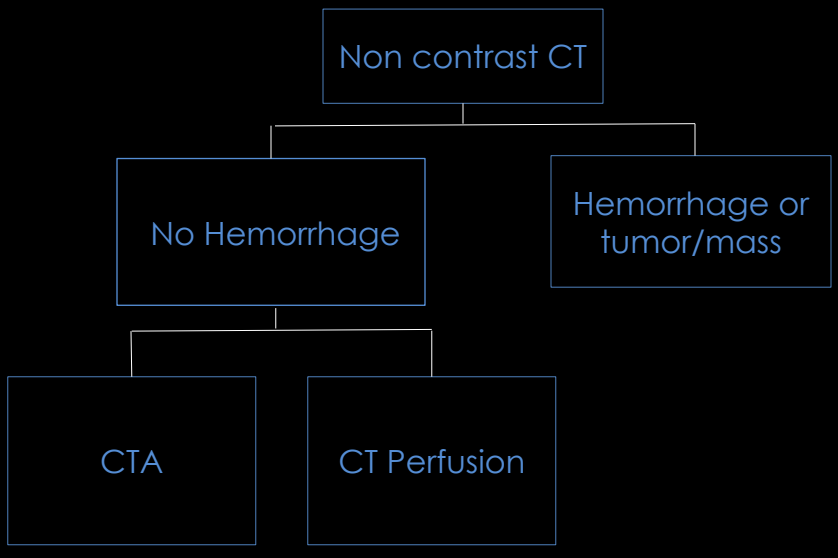

rCBV
rCBF
MTT(s)
Tmax(s)

62



63

Acute Stroke – Imaging Evaluation

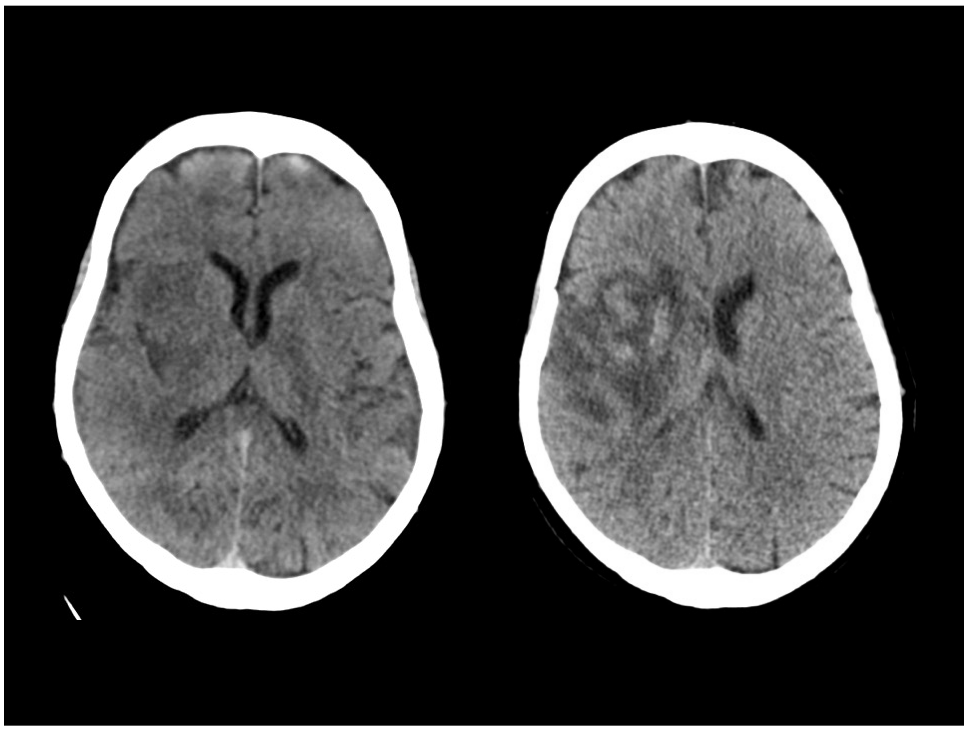


64

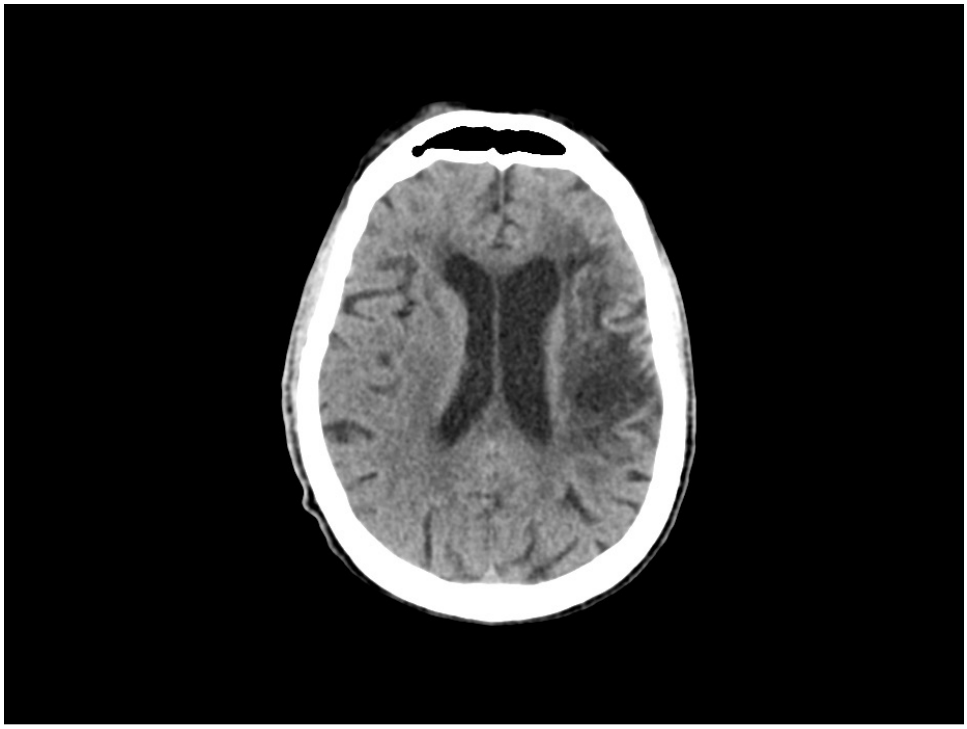
Ischemic Stroke

- Early hyperacute: 0 to 6 hours
- Late hyperacute: 6 to 24 hours
- Acute: 24 hours to 1 week
- Subacute: 1 to 3 weeks
- Chronic: more than 3 weeks

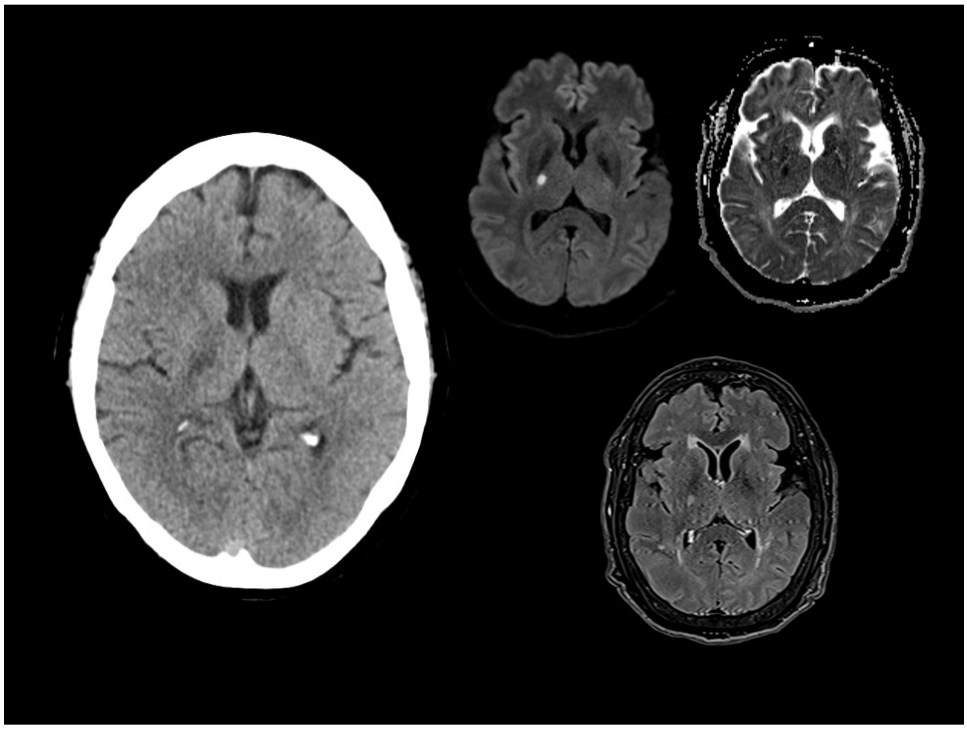
65



66

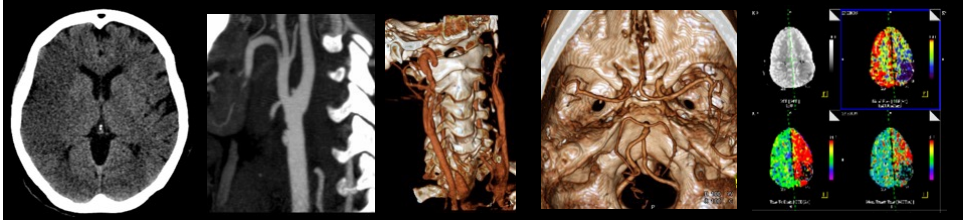


67



68

Acute Stroke Imaging



Jose Gavito-Higuera, MD
Assistant Professor, Neuroradiology Division
Texas Tech University Health Sciences Center
University Medical Center of El Paso
El Paso, Texas
jose.gavito@ttuhsc.edu

69